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the case, if I had been troubled with only a scorbutic corrosive humour. I must leave it to the learned in physic, to make what conclusions they think fit from this true state of my case. I think I remember in some of Dr. Whytt's observations, that if the medicine would not break or bring away the stone, it might cover it with a soft velvet coat, so as to blunt the edge of it, and keep it from vulnerating any part of the bladder. This may probably be my case, if I have still a stone there; and therefore I continue to take daily a third part of the soap and lime-water, which I used, when I took the full quantity.

*X. Extract of the Observations made in Italy,
by the Abbé Nollet, F. R. S. on the Grotta
de Cani. Translated from the French by
Tho. Stack, M. D. F. R. S.*

Read Jan. 24.

1750.

THIS cavern, known so long a time, and celebrated by so many writers, was probably called La Grotta de Cani, because it is commonly on this species of animals, that experiments are made for the curious, who visit it. It lies in the side of a little hill on the eastern border of the Lago di Agnano, between Naples and Pozzuolo. It is not suffer'd to stand open, but is under the care of a man, who, at about an hundred yards from it, keeps a natural stove *, that is, a small building, level with the

* Stofe di San Germano.

with the ground, divided into five or six rooms, which are so hot from the nature of the soil, that patients go thither to sweat by order of the physicians.

The grotto, of which I am to give an account, is not dug into a rock, but into a sandy earth, which however is of sufficient tenacity and consistence to keep together without tumbling down, tho' the sides or walls are cut perpendicular. It is somewhat more than three feet wide, near two toises (or twelve feet) long ; five or six feet high at the entrance, and a little less than three feet at the inner end.

Tho' the ground is a little sloping from within outward, and much more so from the door to the road, which is about five yards from it, and runs along the foot of the little hill ; yet one walks directly into it, as upon level ground, without the assistance of steps to go up or down : which shews, that the slope is pretty even from the bottom or inner end of the grotto to its mouth, and from thence to the road. The knowlege of this particular is necessary for better comprehending what I have to say in the sequel.

When a person places himself at the distance of some few steps withoutside, and stoops so as to have the eye nearly on a level with the ground of the grotto, newly opened, and well illuminated, he sees a vapour within it, pretty much like that, which appears over a chafing-dish of red coals, but with this difference, that it is more sluggish and heavy ; for it does not rise above five or six inches high. This fluid, which is hardly visible, and seems so subtil to the eye, spreads regularly, and seems to effect an

æquilibrium, as if it were a liquor: its surface, much better terminated than that of other vapours, balances visibly under the air, as if these two substances were unwilling to intermix.

I entered the grotto, and found the ground moist; and I was assured, that that was its usual state. This moisture is observable likewise all around the sides, to the height of ten inches, and no more. Of this you may easily judge by the colour of the earth, which in that part is browner and softer than anywhere else. And yet this moisture never increases to the degree of forming any drainings, or even the least visible drops. Nor is there any saline efflorescence to be perceived, as is seen on the walls of the stoves above-mentioned. After having stood upright some minutes, I could remark nothing more than a slight earthy smell, like that which commonly prevails in subterraneous places, which have been kept shut. But I felt about my feet a gentle warmth, which seem'd to rise about the same height with the vapour already mentioned. — In order to be certain of this, I put down my hand, and had the same sensation as if I had thrust it into the steam of boiling water, at eight or ten inches above the evaporating vessel. From another immersion of my hand, which lasted about a minute, it contracted neither smell nor taste, that I could perceive by applying it to my nose, or laying my fingers on my tongue. A small thermometer, graduated according to M. de Reaumur's scale, which I left on the ground in the grotto for above half an hour, marked 29 degrees above the freezing point. It would probably have risen higher, if the door had not been left open. For, when I made this

this experiment, the heat of the exterior air was hardly 18 degrees.

I went out of the grotto, and having kneeled down at some few steps distance below the entrance, in order to examine the vapour a second time, I observed its waving motions under the air, better than the first time; because now both these fluids had been put in agitation just before. I had scarcely been some moments in this posture, when I felt in my legs and left-hand, which I had laid on the ground to support me, a heat like that, which I had remark'd in the grotto, but weaker. I retir'd a little sideways, bowing down my head so as to view the surface of the earth almost horizontally, and very distinctly saw a vapour similar to that of the grotto, but not rising so high, and seeming to glide along, and follow the slope of the ground.

Hence I conjectur'd, that this fluid, too heavy to rise more than five or six inches, without being confined on every side, spread itself from the cavern, where its source lay, into the places below it; and that it was dissipated there, either by being divided into a large space, or by yielding to the agitations of the air. I imagined further, that the ground adjacent to the grotto might possibly exhale this fluid, which I perceived, as well as the grotto itself, only with the difference of more or less. The warmth, which I felt in my hand, while I kept it on the ground, render'd the last of these conjectures very probable; and the first was converted into certainty by the following experiment.

It is a constant custom to entertain the curious, who visit the grotto, with a well-lighted flambeau,

which is extinguish'd as soon as it is thrust into the vapour. I made the experiment several times myself, and I always saw the flame perish without noise, without that sort of hissing, which is heard when an ignited body is quenched in water, or any other substance that contains a great deal. In examining this phænomenon, I discovered another not less curious. The thick smoke, which appeared immediately after the extinction of the flambeau, remained floating on the vapour ; and, being lighter than it, but heavier than the air above it, it spread between both, and moving outward slowly at first, and afterwards quicker, because the slope grew greater, it plainly indicated the motion and direction of the fluid, that carried it along.

If any one ask, why this smoke did not ascend into the air that was over it, and whence proceeded that degree of gravity so unusual to smoke ? my answer is, that probably it proceeded from the vapour, in which the flame had been smothered. One may imagine, that these two fluids, being better adapted to mix with one another than with the air, were blended together towards the surface of the vapour ; and that the smoke, tho' still the lighter of the two, retained weight enough to remain floating under the surface of the air.

The vapour of the grotto is not the only one, that has been seen moving thus under the air, and spreading from its source into lower places. After great eruptions of Vesuvius, the ditches, cellars, cisterns, and wells, in the neighbourhood of the volcano, and chiefly near the places where the *lava's* stopped, are sometimes found full of a sort of *mofeta*

*mofeta** or damp, which much resembles that of the grotto, excepting that it is not permanent: but while it lasts, people observe, that, after having filled the place of its source, it overflows, runs into lower grounds, and stops in places, that have any cavities; as water does, when a basin is too full †.

After the experiment of the flambeau, that of the dog was performed before me. The keeper of the grotto took the two fore legs of the creature in one hand, and the hind legs in the other. He went into the grotto, in the middle of which he laid him upon his side, and held him down: immediately the dog struggled to get loose, or at least to raise his head out of the vapour: he panted, as if his breath failed him; rattled in the throat and snorted, as if to throw out something, that he did not care to swallow. After being thus tortured for three minutes, his strength failed him, and he lay quite motionless. He was immediately carried into the open air, of which he drew in long draughts, as a person recovering from a fainting fit. In the space of two minutes he was able to get upon his legs, and seemed to be in his natural state. This dog was young, vigorous, of a middle size; and his master assured me, that he had used him for the like experiments almost every day for above six months past.

I took a cock, and having carried him into the grotto, I plunged his head into the vapour. Scarcely was it in, when he strained to vomit. And indeed, the food, which he had taken some minutes before,

* *Mephitis*, a deadly or very dangerous exhalation.

† *Neapol. scient. acad. de Vesuvii conflagratione commentarius*, cap. 6.

before, came up in abundance into his mouth : he was suffocated all at once beyond recovery.

To the same trials I put several frogs successively, just caught on the borders of the lake. In three or four minutes they were all stupefied, and remained almost without motion : but altho' I left them in that condition above a quarter of an hour, they soon recovered upon being removed into the open air.

Large flies, a beetle of that tribe called *scarabæi stercorearii*, and some butterflies, which I treated in the same manner, were longer without giving any signs of their suffering, and they came to life after a syncope of longer duration.

By these two last experiments I found, that reptiles and insects hold out against the effects of the vapour longer than other animals. I contented myself with having observed this twice ; because Father La Torre *, who assisted me in making these experiments, assured me, that he had fully convinced himself of the fact, by a series of experiments, which he had made the preceding year with M. Taitbout, our consul at Naples. And indeed, M. de Reaumur having been pleased, after my return, to give me the result of those same experiments, which had been put into his hands, I saw, that a toad resisted near half an hour ; that a lizard was not dead at the end of an hour and a quarter, and that a large grasshopper stirr'd in the vapour, after being more than two hours in it.

Wherefore

* A Somaschian frier, professor of philosophy, and correspondent of the academy of sciences.

Wherefore it cannot be doubted, that this vapour is capable of taking away the life of an animal. If experiments had discover'd to us any pestilential quality, any secret poison in it, doubtless we ought, with most authors, who have treated of *mofeta's*, to range it among those deadly exhalations, whose bad effects are felt, before they can be foreseen ; because they do not strike our senses by any disagreeable smell, or any other quality proper to inspire mistrust. But it is not by the bare extinction of animal life, that a judgment can be formed of them, inasmuch as this effect may equally proceed, either from a substance, that acts by destroying or infecting as a poison ; or from a fluid, which takes the place of another, whose functions it is not capable of performing. It is rather by examining the vapour itself, with a view to know its nature, or at least some of its essential qualities ; and in this view it was that I prosecuted my experiments.

Having cut a sheet of blue paper in two, I laid one half of it on the ground in the grotto, and let it lie there near half an hour. When I took it out, it was somewhat warm, it had contracted no moisture, and its colour, compared with that of the other half-sheet, which I kept in my pocket, underwent no other change than a slight cast inclining to violet.

I placed a water-glaſs, with the mouth downward, at the bottom of the grotto, and left it in that situation long enough to have reason to think, that the vapour had well filled it. I then turn'd it, and set it on its bottom, without taking it out of the vapour, and then poured ſome ſyrup of violets into it, but I could not perceive any change of colour in the ſyrup.

The effect was the same, when I poured off this same syrup into another glass, upon some of the earth fresh taken from the same spot.

I soaked a linen cloth in very strong vinegar, and having tied it to the end of my cane, I put it into the vapour of the grotto ; but tho' I held it there above three minutes, I saw no sign of fermentation.

It came into my mind to try, if the smell of vinegar might not be capable of securing an animal against the ill effects of the vapour. I wrapped the same piece of linen round the mouth of the dog, which had served for the former experiment, and seemed now not to feel any of its effects ; I wrapped it, I say, so as that he might breathe freely ; and while his master kept him lying down in the grotto, I held a sponge imbibed with vinegar to his nose. But all this did not prevent his having the same symptoms, and in the same space of time, as in the former trial. And he recover'd in the same manner, when he was removed into the open air.

As we had passed part of the day in the *Solfatara*, our shoe-buckles, which were of (*tombac*) yellow metal, had considerably changed their colour. I was sorry, that I had not some pieces of the same metal polished, to throw into the vapour of the grotto, in order to see, if we might not discover some arsenical quality in it : but Father La Torre, to whom I intimated my concern, told me, that that was one of the experiments made by M. Tailbout ; and that the metal, after a considerable space of time, still appeared of the same colour as before.

A moment afterwards I found on the ground a bit of leaf-brass, which I had made use of above two hours before,

before, for some electrical experiments: but either it had not changed colour at all; or the difference, if any, was not discernible.

By these experiments, we do not see positively what this fluid is, which quenches flame, and kills animals in the Grotto de Cani; but in my opinion we learn pretty well what it is not. We may say with great probability, that it is neither sulphureous, nor arsenical, nor alcali, nor acid, to the degree of being dangerous, or of doing sudden mischief by any of these qualities. Besides, it makes no impression on the skin of the hand; which might make one believe, that it would make none on the face, eyes, tongue, or perhaps on the internal parts of the body, if it were convey'd in only by the same ways with the food. But let us not stop at conjectures: here are facts, which answer these questions.

Embolden'd by all the experiments above-recited, and by the inferences, which I drew from them, I thought I should not commit an imprudent action, in plunging myself into the vapour, with the precaution however of not breathing it, and of staying but very little time in it. I kneeled down in the grotto, and leaning both my hands on the ground, I bowed my face forward to within two or three inches of the bottom; keeping my eyes open, my tongue a little way out of my mouth, and holding my breath for a moment.

In this first immersion I felt a touch pretty much like that of boiling water containing some salt; which instantly made me shut my eyes, by a motion natural to that organ, when any thing but quiet pure air strikes it. But it was not attended with any painful

impression, or any sort of taste on my tongue, which remain'd uncover'd all the time I held my face down, which was three or four seconds.

The more I studied the vapour of the grotto, the less I found it capable of acting as a poison. I persuaded myself, that one may make an animal swallow some of it with his food, without endangering his life: and to be certain of this, I gave some bread, soaked a long time in the vapour, to a chicken, which eat it without reluctance, and shew'd no signs of being incommoded thereby.

As I was on the point of quitting this famous grotto, never to see it more, in all probability, I was very desirous, that nothing might be forgot, that could be done there. I was resolved in particular not to omit certain trials, of which one cannot form a right judgment, without having actually made them; and which I would not afterwards presume to require from the complaisance or zeal of a correspondent. I took a strong fancy to breathe this vapour myself, which had hitherto been one of the chief objects of my inquiries. Doubtless this would have been a blameable rashness two or three hours before: but whosoever will recollect all the experiments preceding it, especially that of the chicken, and the example, so often repeated, of animals plunged into this vapour, which are never suffocated therein suddenly, and feel no ill consequences from what they suffer'd in it, will see, that at most I exposed myself to breathe once disagreeably; and accordingly that was all, that happened to me. Having advanced my face to the very surface of the vapour, I attempted to take in breath gently. I was sensible of something suffocating, much

much as when a person has his mouth near a large tube of a hot brasier, or when he goes into a very hot and moist stove. I also felt a slight acrimony in the throat and nose, which made me cough and sneeze. But this trial, which I must own was of short duration, occasioned neither sickness at stomach, nor head-ach, nor any other inconveniency. It confirmed me more than ever in the opinion, that this vapour had none of those venomous or pestilential qualities, which are attributed to *mofeta's*, tho' it is classed among them by several authors.

For my part, when I consider the quickness of its action; I see nothing in it but a fluid, the nature of which is indeed unknown to me, but which is specifically heavier than the air, and does not easily mix with it. And this I take to be sufficient to account for the effects, that are observed in the grotto.

It is well known, that the air is, for land-animals, the only proper fluid for respiration ; and for this purpose it must have a certain degree of purity and density. A quadruped or a bird would soon perish for want of breath in the best and most wholesome water ; and nobody could live long in a very thick smoke, tho' it were that of burnt straw, or any other more innocent matter ; he would soon be smother'd in it. The same thing may be said with regard to flame ; it extinguishes necessarily, when it is deprived of air ; no other medium suits it. Now, of what nature soever the vapour of the grotto may be, from the moment we are certain, that it is not air, or that it is not an air like that of the atmosphere, it is easy to see, why animals cannot breathe it. They perish in it, not as poisoned, but barely are drowned in a fluid incapable of supplying the place of the air, which they

want: and it is the same with regard to the lighted flambeau.

Several reasons render this explanation plausible. First, we have seen, that the animals, which suffer'd most in the grotto, recover speedily and certainly, upon being carried into the air before they are quite dead. If the symptoms which they have undergone, proceeded from a matter, which had injur'd some noble part, infected the mass of blood, or stopp'd the course of the fluids by some contraction or irritation excited in the solids; ought not the evil to last, in consequence of what was done, until the body were quite cleared of this matter? They no longer throw the animals into the lake, after taking them out of the grotto. It was a vulgar error of long standing, but now entirely banished, to believe, that that water was to be their antidote. It would rather give the finishing stroke to drowning them, if they were put into it, and had not strength enough to swim, and hold their head above water.

Secondly, a sort of resemblance is observed between the animals, that suffer in the grotto, and those, that are confined in an air extremely rarefied. It is well known, that reptiles and insects die with greater difficulty and more slowly in the exhausted receiver of the air-pump than quadrupeds and birds: with regard to these last especially I have frequently observed, that, when they are employ'd for the experiments of the air-pump soon after feeding, they perish in an instant, in straining to vomit. All this has a good deal of resemblance with what I have above related of the cock, frogs, lizards, beetles, flies, &c. which were confined in the vapour of the grotto.

Thirdly,

Thirdly, in fine, I have been informed by Mr. *Serrao*, secretary of the Neapolitan academy of sciences, by Father La Torre, and several other learned men of the country, that in the dissection of animals suffocated in the grotto nothing remarkable was observed, excepting that the lungs were a little too flaccid or collapsed ; a state similar enough to that of an animal dead purely for want of air.

However, this testimony is not to be confounded with what the same M. *Serrao* relates of the effects of certain *mofeta's*, which were seen for some time in the neighbourhood of Portici, after the eruption of Vesuvius in 1737. Altho' these dangerous exhalations resembled that of the grotto in many respects, yet they differ'd from it in several others : they were colder than the air of the atmosphere commonly is in summer ; they turned the flesh of animals livid, that were kill'd by them ; they gave a bad taste to water. Nevertheless, by attentively perusing the examination * made of them, we find much reason to believe, that if these transitory or accidental *mofeta's* had any bad quality more than the vapour of the grotto ; it was not so much by that quality that they were either mortal or offensive to animals immersed in them, as by reducing them to an impossibility of breathing their proper element.

* See chap. 6. of the work above-cited.